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V.

STUDIES ON THE TRANSFORMATIONS OF MOTHS OF
THE FAMILY SATURNIIDÆ.

BY A. S. PACKARD, M. D.

Presented February 8, 1893.

THE larval characters of the members of this interesting group, especially those features which are congenital, tend to show that the family has originated from some spiny group, and most probably, when we take into account the transformations of *Aglia tau*, from the Cera-tocampidæ, although none of the latter spin a cocoon. During the evolution of the group they underwent a change in shape, from a rather long and slender form to a thick heavy body, with a thin integument, the result perhaps of an unusually stationary mode of life. The imagines also underwent a process of degeneration, as seen in the atrophy, total or partial, of the maxillæ, and in the loss of veins in their very large but weak wings; though the loss of strength of flight is somewhat compensated for by the remarkable development of the olfactory organs, or antennæ.

This family also appears to be a closed type; viz. none of the higher or more specialized Bombyces appear to have descended from it (unless possibly the Cochliopodidæ), the type representing a side branch of the Bombycine tree which late in geological history grew apart, and reached a marked degree of modification, resulting in the possession of adaptive characters which were not transmitted to later forms. It seems probable that the type was a Miocene Tertiary one, which has lingered on in Eastern America (North and South), and in Eastern Asia, as well as in Africa, while it has become nearly extinct on the Pacific shores of North and South America, and in Europe.

Saturnia (in its restricted sense) the most generalized Genus of its Family.—In the European *Saturnia carpini* and its allies, and our Pacific coast species, *Saturnia mendocino* and *S. galbina*, the larva of the former species having been described by the late Henry Edwards (Proc. Cal. Acad. Sci., Dec. 17, 1877), we have perhaps the most generalized and primitive members of the family. In the larva of

Saturnia carpini, for a specimen of which I am indebted to M. P. Chrétien of Paris, the setiferous tubercles are of the same size and shape on the abdominal as on the thoracic segments, there being no differentiation in shape and size or color, such as occurs in all the other genera, except that the second and third thoracic dorsal tubercles bear one or two bristles much longer than those on abdominal segments 1 to 7, and about as long as those on the 8th abdominal segment. There are *six* tubercles on this (8th) segment, being the same number as on the seven segments in front; on segment 9 there are four tubercles, and two on the 10th segment, i. e. the suranal plate. The same number of tubercles on the 8th abdominal segment also occurs in *Saturnia mendocino** of California. Likewise the same number is present in the European *S. pyri*, judging by the figure and description in Duponchel et Guenée's Iconographie (II., Pl. I.), and the statement, "On ne compte que quatre tubercules sur le premier anneau, de même que sur le dernier, tandis que les intermédiaires en ont chacun six." It is also figured in Hübner's Schmetterlinge.

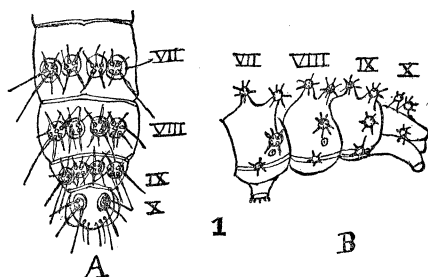


Figure 1, A, represents a dorsal view of the end of the body of the larva of *Saturnia carpini*; B, the end of the body of *S. pyri*, copied from Duponchel.

* We copy Mr. Edwards's description of this larva, to show that the same characteristic of *six* tubercles on *all* the abdominal segments 1 to 8 occurs in the Pacific coast species of the genus: — "*Full grown*. Head small, rough, purplish brown, somewhat withdrawn into the second segment. Ground color of the body, pale yellowish green. On the second and anal segments are four tubercles each, bright orange-red, with black hairs springing from them, and on each of the other segments are six similar tubercles, those of the anterior four being the largest. Head and body thickly clothed with whitish hair. Laterally there is a pale yellowish fold above the spiracles, which are orange with a darker ring. Feet and under side purplish brown. Length 2.25 inches. Food plant, *Ardistophylus tomentosa*."

Indeed, the extremely generalized form of the larvæ of this genus is clearly shown by the fact that in *P. cecropia*, and all the other more specialized and hence later genera, there are only five tubercles on the 8th abdominal segment, those corresponding to the two middle ones of *Saturnia* having, probably during embryonic growth, coalesced. The embryos of these moths should therefore be examined shortly before hatching to ascertain whether this be not the fact. Meanwhile it is not unreasonable to suppose that all the more specialized genera must have been derived from a *Saturnia*-like ancestral form, i. e. a larva of cylindrical shape, with all the tubercles, whether thoracic or abdominal, of the same size, shape, and color on all the segments; those on the 8th abdominal segment being of the same number (six) as on the segments in front.

The single median tubercle on the 8th abdominal segment of the more specialized Saturnian larvæ represents the "caudal horn" of Sphingæ, *Bombyx mori*, and the Notodontian genus *Pheosia*, and is evidently the result of fusion before the end of embryonic life of what were originally two separate tubercles, like the two separate ones of *Saturnia*. We are thus able to confirm the suggestion of W. Müller, who first identified the "caudal horn" with the two dorsal tubercles on the 8th abdominal segment of the Saturniidae.*

Thus as regards the tubercles the species of *Saturnia* are on the

* W. Müller, Südamerikanische Nymphalidenraupen, 1886, pp. 249, 250. Müller remarks:—

"So erscheint es berechtigt, für das Schwanzhorn der *Sphingide* die gleiche Genese anzunehmen wie für den unpaaren Dorn der *Saturniade* auf 11. Beide sind entstanden aus den Stützgebilden der beiden Borsten 1 auf Segment 11. . . . Weiter finden sich bei einer Raupe, augenscheinlich den Saturniden angehörig, in einem früheren Stadium *Sds* auf 2, 3, *Ds* 11; mit der nächsten Häutung verschwinden die sämtlichen Dornen. Bei *Brohmea ledereri* finden sich im 3. (?) Stadium *Ds* 11, *Sds* 2-10, 12, *Sst* 4-11, von welchen Dornen die *Ds* 11, *Sds* 2, 3 stark entwickelt, die anderen klein, unscheinbar sind. Im 4. (?) Stadium sind die *Ds* 11, *Sds* 2, 3 wohl entwickelt, die anderen Dornen sind kaum nachweisbar. Im letzten Stadium bleibt nur eine Warze an Stelle des *Ds* 11; es erhält sich also der Rest von *Ds* 11, am längsten.

"Mir scheinen alle diese Gründe zur Annahme zu drängen, dass das Schwanzhorn der Sphingiden der Rest einer reicher entwickelten Bedornung ist, einer Bedornung, die vielleicht mit der heutigen der Saturniden auf gleichen Ursprung zurückzuführen ist, so dass das Schwanzhorn der Sphingiden und der Dsdorn der Saturniden im vollen Sinn homolog sind."

See also E. B. Poulton in Trans. Ent. Soc. London, 1885, p. 302, and in later papers; also A. S. Packard, Proc. Bost. Soc. Nat. Hist., XXV., 1890, pp. 99, 103, foot-notes 1, 2, 3. Also compare our Figures 3-6, 8-10 *d'*, and the references to them in the text. Also Grote's N. A. Lepidoptera, Bremen, 1886, pp. 16, 54.

same plane with the embryo, just before exclusion, of the more highly specialized forms of the group Attacinæ. The great size of the Attacinæ, particularly *Attacus atlas*, appears to be a sign of recent specialization, and the small size of *Saturnia*, aside from its other features, suggests that it is a generalized form, not departing greatly from the normal size of the members of the superfamily Bombyces.

And here an interesting problem in zoögeography occurs. Are the species of *Saturnia* (in the restricted sense) — three in Europe, and two in the Southwest and Pacific Coast of North America, occurring where the Attacinæ do not exist at all, or only rarely — the relics of a Saturnian fauna from which the group Attacinæ has been eliminated by geological extinction, as the sequoia, cypress, magnolia, and other Tertiary plants have been rendered extinct in Europe, or may the view be taken that the Attacinæ have never had a foothold in Western Eurasia and North America?

Should we use the characters drawn from the number and arrangement of the tubercles of the larva in classifying the Saturniidae, we might divide the family into two groups, as follows: —

A. Six tubercles on the 8th abdominal segment; the tubercles in general over the body all of the same size. Generalized forms.

Subfamily 1. *Saturniinae*.

B. Five tubercles on the 8th abdominal segment, the median one double; the tubercles in general more or less differentiated or specialized in size and color. Specialized forms.

Subfamily 2. *Attacinae*.

An interesting series of parallelisms may be observed in comparing the early and later stages of the larvæ of this family. For example while the late embryos of the Attacinæ are perhaps paralleled by the fully grown larva of *Saturnia*, the fully grown larva of the most or one of the most generalized Attacinæ, *Platysamia*, is on the same plane of specialization as the larva of *Callosamia* in its third stage.

THE LIFE HISTORY OF *PLATYSAMIA CECROPIA* (Linn.).

From some eggs received from Mr. H. Meeske, of Brooklyn, N. Y., the larvæ hatched out at Providence during the night of June 14.

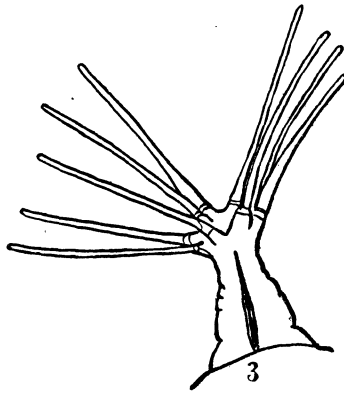
Egg. — It is large, flattened, oval-cylindrical. Length 2.5, breadth 2 mm. The shell is dull chalky white, is seen under a triplet to be pitted, but under a half-inch objective the pits are seen to be in close irregular wavy parallel rows, the pits themselves showing a tendency to be grouped into twos or threes.

Larva, Stage I. — Length when first hatched (June 15), 6 to 7 mm. On emerging from the egg the larva is mostly black, the head, body, and hairs are jet-black, but the tubercles are pale yellowish green, the hairs or bristles they bear being black; the abdominal legs also are pale, the thoracic ones black; shortly after emerging the larva turns entirely black. One larva was observed drawing itself slowly out of the hole it had gnawed in the egg, having eaten its way through the egg-shell at 11.30 A. M., June 15. It was mostly black, but the pale yellowish green tubercles were flattened down close to the body, and the hairs or setæ in each verticil or pencil were united in one pencil-like mass and bent to one side on the body. The abdominal legs were pale livid, the thoracic ones black. In ten minutes more the tubercles had become erect, higher and longer (probably swelled out by the presence of the blood), and by this time the hairs had assumed their radiate arrangement.

In one or two minutes more, viz. from 11 to 12 minutes after extricating itself from the egg, the tubercles had all become of full length, and erect, and the black setæ, or hairs, had now spread out in a verticillate way, as normal. In an hour more the larva had turned perceptibly darker, and in three quarters of an hour more it had turned entirely black. The spiracles, however, are yellowish green, and thus are rather conspicuous. The body is stout and thick, the head is as wide as the body. On the prothoracic segment are four dorsal tubercles, two on each side of the median line. Along the body are six rows of tubercles, each usually bearing about five radiating setæ; those of the two dorsal series are larger than the subdorsal ones. The tubercles are rather short and stout, fleshy; and are one half to two thirds as long as the bristles. The latter are stout, taper to the end, which under a half-inch objective is seen to be blunt, slightly bulbous, and clear, so that these setæ are evidently glandular in function; they are slightly rough with rudimentary spinules. On the 8th abdominal segment, instead of two tubercles, one on each side of the median line, as on abdominal segments 1 to 7, there is a single median tubercle, about twice as large round as those on each side, though no higher, and it is evidently the result of the condescence in the embryo stage of two tubercles, such as are to be seen on the segments in front. It is transversely broad at base, and also bears eight or ten setæ, or nearly twice as many as the homologous tubercles on the other segments. The thoracic feet bear at their tips three lancet-shaped flattened acute tenant hairs; while the abdominal legs bear about 16 crotchets.

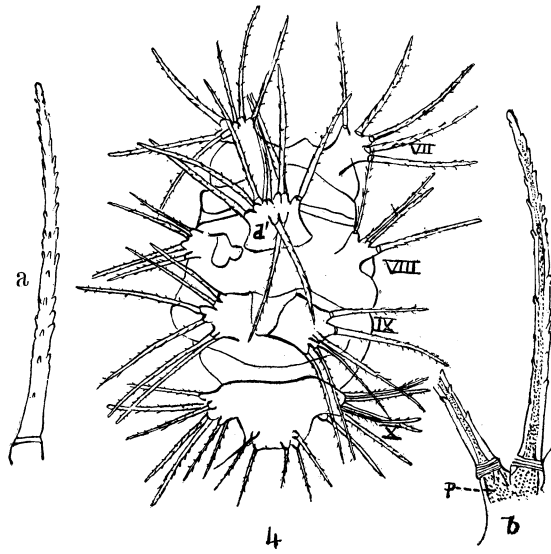
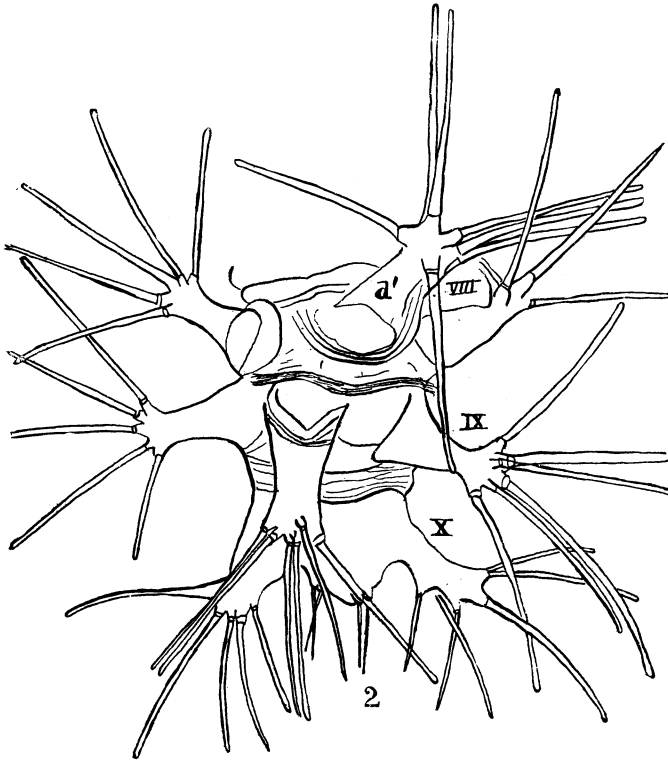
Figure 2 (Plate I.) represents the last three abdominal segments; VIII. bearing the median double tubercle *d'*, and IX. the 9th pair (the right subdorsal tubercle on the 9th segment not being drawn); X. the suranal plate with its armature, the two lateral tubercles, bearing each six setæ; the tubercles in front usually bear five setæ.

Figure 3. The double median dorsal tubercle of the 8th abdominal segment, showing a light median furrow, the probable line of union of what in the embryo were originally separate tubercles; it bears ten setæ, arranged in two lateral groups of five each.



Stage II. — (Described one or two days after moulting.) Length 14 mm. The head now is quite small, scarcely one half wider than the body; it is entirely black.

The body is dull dusky livid greenish; the tubercles are somewhat yellowish at base on the conical portion, but *the slender chitinous portion is shining black*, and the radiating bristles are all black; one or two of them are longer than the column or chitinous portion of the tubercle. *The thoracic tubercles are slightly longer than those on the abdominal segments*, and the single median one on the 8th abdominal segment is slightly larger than those on the 7th and 9th segments, and is now about twice as thick as those on the side, and bears eight bristles, the lateral ones on the same segment bearing five. The prothoracic segment is a little darker than the others; it bears a chitinous black plate about four times as broad as long, bearing on the front edge four setiferous tubercles of equal size, one at each end, and with two yellow spots. The tubercles in general are now long and slender, with a conical base, the stalk contracted and rather slender in the



ARMATURE OF ATTACINE CATERPILLARS.

middle, the head enlarged and giving off the four or five bristles. *There are now five rows of indistinct black spots, along the body, like those so distinct in Samia cynthia*, but they are not distinctly seen; those of the median row are somewhat diamond-shaped. One was observed while moulting, June 23. Length 15 mm., becoming 17 mm. The larva is more like *S. cynthia*, as directly after moulting it is yellowish, and the five rows of black spots are now very conspicuous, the median dorsal ones being more or less diamond-shaped; but the tubercles and spines are all black. The head is black, but pale on the labrum.

In this stage, just before moulting, it spins a floor of silk longer than its body, on which to stand, its crotchets being fastened in it during the process of exuviation.

On June 28, at 9 A. M., one had just moulted, having been seen to draw itself out of the crumpled end of its skin. All the tubercles of the two dorsal rows are amber-yellow, except those on the 2d and 3d thoracic segments, which are a little larger than the others, and deep orange. The four prothoracic and also the two lateral rows are pale greenish, without any flesh tints. At this time both the head and the prothoracic segment are entirely pale greenish yellow, and the body is deep yellow, like that of *S. cynthia*, with the black spots very conspicuous; all the spines, however, on all the tubercles are black. The tubercles* are now much stouter than before, *but are not yet spotted on the sides with black, as they are later in this stage*. Its length soon becomes from 18 to 20 mm.

Half an hour later (9.30 A. M.) it had not changed, but by 11 o'clock A. M. the four prothoracic tubercles (rather, however, three, as the inner one on the right side is wanting, another malformation) and the 2d or lower lateral row had turned dark, while the upper lateral row had begun to turn dark at the base. The black patches on the sides of the dorsal tubercles had also begun to appear; also the region at the base of the antennæ, as well as the clypeus and labrum, had turned pale.

At 12.45 P. M. the black tints became more pronounced. The prothoracic spines had all turned, as well as the two lateral ones, except those on the 6th abdominal segment, which were still pale at the end. In the 1st or upper lateral row the tubercles were pale at the end. Of the two dorsal rows, those of the abdomen are lemon-

* One tubercle on the left side of the 3d abdominal segment has no spines, a malformation never before observed.

yellow, and dusky at base, the two on the 9th segment being pale sea-green, with a black patch or band on the side extending around behind. The double large median tubercle on the 8th abdominal segment is now lemon-yellow, like those in front, with a large trapezoidal black patch on the posterior half, which does not reach up as far as the origin of the black spines. The spiracles are ringed with black.

By 3 P. M. all the dark portions and markings had become jet-black; there are now ten black spots on each segment, and the larva had now attained a length of 18 mm.

Stage III. — Length 20 mm. The following is the description of this stage when fully completed, and the color of the markings fully established. The head is black, with the clypeal and labral regions green, while an irregular green band passes back from the labrum above the eyes to the side of the head, the latter being now about two thirds as wide as the body. The larva is cylindrical, the tubercles are high and thick, the longer bristles being as long as the tubercles themselves. All the prothoracic tubercles are black; the two dorsal ones on each side being united by a black shining bridge at their base. The tubercles of the 2d and 3d thoracic segments are now deep coral-red, with black bristles; they are larger than the abdominal ones, and are very showy. The two dorsal rows of abdominal tubercles are lemon-yellow with black spines, and black at the base behind and on the sides. The single median spine on the 8th segment is nearly twice as thick as the others of the same segment on each side. The two lateral rows of tubercles are black, *with the ends of a beautiful pale blue*, approaching lapis-lazuli. There are a median and two lateral rows of black spots, situated between the spines; the median dorsal series consists of two spots, one in front of the other; while the spiracular series consists of two, one in front, and the other behind, but lower down than the spiracle. In some examples the body is yellowish.

The thoracic legs are black; those of the abdominal region green, but shining black on the outer side; the anal legs with a shining black patch nearly covering the outside of the leg. In one example the tubercles are aborted on the left side of the 2d and 3d thoracic and the 1st abdominal segments.

Stage IV. — July 12, one had just moulted, the end of the body having just been withdrawn from the cast skin at 11.10 A. M. Length 25 mm. The head and prothoracic segment are green, while all the prothoracic tubercles and those of the subdorsal and infrspiracular

rows are a beautiful pale cobalt-blue. The two dorsal tubercles of the 2d and 3d thoracic segments are deep orange (afterwards becoming coral-red); the homologous dorsal abdominal ones, including the single median one on the 8th segment, are lemon-yellow. The body is tinged with blue, especially on the thoracic segments. The spiracles are white with a fine black circle, and contain a straight linear central mark. All the bristles are still long, radiated, and are black.

In this stage the four dorsal tubercles of the 2d and 3d thoracic segments are larger than any others on the body; and those on the first seven abdominal segments are of nearly uniform size; the single one on the 8th segment being nearly twice as thick.

In this stage the eight to ten black dorsal and lateral spots dwindle in size, becoming less conspicuous; but the black spots on the side of the head and on the sides of the abdominal legs are large and distinct.

Stage V. and last. — Length 40–45 mm. One which moulted about the 9th of July had a pea-green head and prothoracic segment; the head marked with a roundish black spot on each side, below which is a large black patch bearing the ocelli, and lower down a black spot. The body is pea-green, washed with cobalt-blue along the back, beginning with the 2d thoracic and ending with the 8th abdominal segment, *and the black spots along the back and sides have disappeared.* Of the lowest lateral row of five small tubercles, the three thoracic and those on the first two abdominal segments are black; those on the third and fifth are blue at the end, but the bristles are black. All the prothoracic, and the two rows of lateral (the subdorsal and infraspicular) tubercles are cobalt-blue. The two dorsal tubercles of the 2d and 3d thoracic segments are deep coral-red; the corresponding ones on abdominal segments 1 to 7, and the single one on the 8th segment, are lemon-yellow.

The spiracles are now white with a narrow black ring, but no central dark line. The thoracic feet are green, but black at the end. *The black spots on the sides of the pea-green abdominal feet are now obsolete*; the plantæ are bluish.

July 25–26. Some individuals were observed while moulting into the last stage, their length after exuviation being 47 mm.; they became after feeding still larger. This stage differs from Stage IV. in *the tubercles on the first abdominal segments being much larger and more spherical than before, and orange rather than yellow*, and thus in size, color, and the spines being more like the four coral-red thoracic tubercles than the other dorsal abdominal ones.

On the 1st abdominal, as well as the thoracic round-headed tubercles,

there is a circle of eight black flattened knobs representing the circle of spines above at the end; also the black spines on the median 8th abdominal tubercle are much shorter and stouter than before, as are all the spines on the other tubercles.

In all the five larvæ, except one, and in those of both stages (IV. and V.) the rows of black intertubercular spots have disappeared, the one retaining them (40 mm. long) having a single row of ten dorsal black rounded spots, two on a segment, along the abdomen.*

On the inside of the base of the infraspicular row of turquoise-blue tubercles is a black spot, wanting on the 3d thoracic, but present on the 2d thoracic tubercle.

Recapitulation of the more Salient Ontogenetic Features.

A. Congenital Characters.

1. The setæ in Stage I. blunt, slightly bulbous, and glandular.
2. The tubercles are all of the same size.
3. Body in Stage I. dark, almost blackish, green, head jet-black; tubercles yellowish green.
4. The homologue of the "caudal horn" shows plainly its double origin.
5. The difference between the colors of the larva of the first and last stages very marked.

B. Evolution of later Adaptational Features.

1. The thoracic dorsal tubercles in Stage II. and onward are longer than the abdominal ones.
2. Five rows of indistinct black spots along the body in Stage II., not so distinct as in *S. cynthia*, the body being still dusky green. (These do not originate from lines.) At the end of Stage II. the larva is more like *cynthia* of the same age, the body being more yellow, and the black spots more distinct. The spots disappear at the end of Stage IV.
3. The thoracic dorsal tubercles deep orange; their homologues on the abdominal segments amber-yellow.
4. The tubercles at the end of Stage II. and in Stage III. spotted on the sides with black.

* This larva wants the right 3d thoracic tubercle, and also the right 2d abdominal one. In another larva of the same stage the right 1st abdominal tubercle is partly atrophied, half the normal size, and with only two or three rudimentary spines. These tubercles and their spines in confinement are apt to be atrophied from disease; this also occurs in *S. cynthia* and *T. polyphemus*.

5. In Stage III. the dorsal tubercles of 2d and 3d thoracic segments showy coral-red. The subdorsal and infraspiracular tubercles tipped with pale blue; in Stage II. the same tubercles are almost entirely pale blue.
6. The head becomes green in stage IV., with a black spot on the side.
7. The larva is most gaudily colored and conspicuous in the last two stages; while in *S. cynthia* there are not so marked differences between the different stages, though the last is the most variegated owing to the beautiful turquoise-blue trappings.

NOTE ON THE FRESHLY HATCHED LARVA OF *PLATYSAMIA*
GLOVERII.

Young Larva, just hatched. — May 15. Just as it slips out of the egg the body and head are jet-black, but the spines are white, though their tips at the origin of the hairs are black. In a few moments, however, the spines turn jet-black; the hairs arising from them being white.

NOTE ON A YOUNG *PLATYSAMIA* LARVA FROM ARIZONA.

I have had an opportunity, given me by Dr. Riley, of examining several freshly hatched larvæ from Arizona, in the collection of the U. S. National Museum (No. 3053, box 13.75). They seem to be congeneric with *P. cecropia*, but differ in the following respects. Head black, body darker, the spines dark towards the end. The spines are of the same general shape, but the trunks are a little shorter and thicker, more stumpy, while the bristles arising from them are a little longer.

As *Platysamia polyommata* Tepper is the only species from "Southern Arizona," it is perhaps the young of this form, but more likely is *P. gloverii*, as I possess the mature larva of this species collected by the Wheeler Survey party on the Sierra Amarilla in New Mexico. It only differs from another fully fed larva of this species from Salt Lake City in having all the spines slightly slenderer.

THE LIFE HISTORY OF *CALLOSAMIA PROMETHEA* (Drury).

The larvæ are at first gregarious, feeding side by side on the under side of the leaf.

Egg. — Oval-cylindrical, somewhat flattened; the surface pure white, somewhat shining. Under a half-inch objective the shell at first

seems to be entirely smooth and shining, without any markings, with neither pits nor polygonal areas, but after further observation very faint, irregular, moderately large polygonal areas, with faintly raised edges or boundaries, can be detected. Length 1.8, breadth 1.5 mm.

The egg of *C. angulifera* is the same as *C. promethea* in shape and color, though mine are slightly smaller, and the polygonal markings appear to be even fainter than in *C. promethea*.

In the Attacinae the eggs present generic, specific, and perhaps varietal characters; this of course depends on the structure of the lining of the oviduct, and it may be asked what natural selection or the influence of external surroundings have to do with the differences in the shape, structure, and markings of eggs.

Larva, Stage I.—Described a few hours after hatching. Length 5 mm. The head is wider than the body in the middle, and as wide as the prothoracic segment; black, with a broad transverse whitish band crossing the clypeus, including the apex and a large portion of the clypeus itself, the labrum and base of the antennae pale. The thoracic tubercles, at first lemon-yellow, become afterwards dusky greenish, while those of abdominal segments 1 to 7 are lemon-yellow; all give rise to black bristles, the longer of which are *about twice as long* as the tubercles themselves, being much longer than in the other Attacinae of the same stage, while the tubercles themselves are smaller in proportion. The thoracic tubercles bear seven or eight, and the abdominal six bristles, one of which is often longer than the others.

The body is lemon-yellow, very conspicuously banded crosswise with black. The prothoracic segment is yellow; dusky along the front edge; or yellow with one or several black spots; on the hinder edge is a broad black transverse band ending on the lowest lateral tubercle, which is yellow, and a little larger than the dorsal ones on the same segment. The front and hinder edges of each succeeding segment of the body are black. The anal legs have a large black spot on each side. The three tenant setae on the thoracic feet are broad and lancet-shaped, and there are 16 crotchets on the abdominal legs.

The single median tubercle on the 8th abdominal segment is evidently double in its origin, being twice as broad as long at the base, and there is a median space between the two sets of setae, there being two tops or crowns, from each of which arise five setae; and it is larger than the others, its greatest diameter being the transverse one. This and the two dorsal and lateral tubercles on the 9th and 10th segments (suranal plate) are dusky or blackish green, and are of the same hue as those on the thoracic segments, and *they are a little larger than*

those on abdominal segments 1 to 7, those being yellow. All the bristles are jet-black, and there are none of any other color. They are finely spinulated, the spinules rather dense; they taper to the acute end, and are clear and probably glandular. It is to be noticed that the body is transversely banded with black; that the dorsal tubercles of the three thoracic and the last two abdominal segments are already in this stage differentiated in color and size from those of the first seven abdominal segments; indeed, the larva is much variegated, being showily banded, with great contrasts of color.

Mr. Bridgham's specimens of Stage I. were observed on July 15, and were fed on the sassafras and wild cherry. The second stage was drawn on July 23d.

Stage II. — Length 10 to 12 mm. The head is not quite so wide as the body behind the middle, being much smaller in proportion to the body than before; it is black, with a sinuous broad conspicuous *whitish* (not yellow as in Stage I.) band passing across the clypeus, so as to include the apex, and curving down towards the antennæ. The ground color of the body is *whitish* instead of yellowish, so that the transverse black bands, though narrower, are more conspicuous than before. On the 1st thoracic and 9th abdominal segments are two dorsal and two lateral black tubercles, one as in Stage I., but on all the other segments except the 10th abdominal the tubercles are now yellowish with black spines; all the tubercles are situated on the white portion of the body, the black bands being situated between them. The single median tubercle on the 8th abdominal segment is now *yellowish*, and distinctly seen to be double, being very broad, and each side provided with a crown of about five spines. There are five or six spines to each tubercle, and many are black, and much shorter and stouter than in the previous stage, the outer ones being about as long as the tubercles bearing them are high, the central inner one longer. The round black spot on the side of the anal leg differs from that in Stage I. in being curved, boomerang-shaped. The thoracic legs are black, and the abdominal ones pale yellowish. *In this stage the dorsal tubercles on the 2d and 3d thoracic segments are of the same size and color as those of abdominal segments 1 to 7; the differentiation in size and color of the four thoracic tubercles having not yet taken place.* It is to be observed that in Stage I. the dorsal tubercles on all these thoracic segments are black, and the median one on the 8th abdominal segment is also black.

Bridgham's figure and Riley's specimen, from which the foregoing description has been drawn up, agrees with Riley's description.

Figure 4 (Plate I.) represents a dorsal view of the last four abdominal segments (VII.-X.) with the medio-dorsal tubercle (*d'*) on the eighth uromere (VIII.), bearing ten setæ, two of them arising one on each side of the median line; *a*, a seta from one of the dorsal tubercles on the 9th segment; *b*, one from the 7th segment showing the medullary fluid supposed to be the poisonous secretion, though there is no secretory cell visible at the origin of the spine; the spine is dark and rather opaque.

Stage III. — (Described from an alcoholic specimen in the author's collection.) Length 15 mm.; width of head 2 mm. The head is marked in general as before, but the hairs are smaller and less numerous. *The sinuous white band in front is much wider than before, being in front fully three times as wide as the black line connecting the eyes; the band being narrower on the sides above the eyes. The head is much narrower than the body, which is now stout and thick. The two transverse black bands or rings on each of the thoracic and abdominal segments have now disappeared, only faint traces of them being left here and there, the most persistent traces being a minute linear black spot situated on the side behind the spiracles. The prothoracic tubercles are black, and about half as long and large as the 2d and 3d thoracic dorsal ones, which are whitish, with a black ring at base; the lateral ones being black-brown. All the dorsal abdominal tubercles are but a little smaller than the thoracic ones, and all, both dorsal and lateral, are black-brown, except the single large dorsal tubercle on the 8th segment, which is now very large and fully twice as thick as the largest dorsal ones elsewhere, if not more; it has four spines on each side, and two central ones. In all the tubercles the spines are now short, and no longer than the thickness of the tubercles bearing them. The black curved line on the side of the anal legs is now more curved than before.*

Stage IV. — (Described from Mr. Bridgham's colored sketch.) Length 20 mm. *The head is now yellow, with two black dots in front, and a narrow black transverse line connecting the eyes and antennæ; the head is about two thirds as wide as the body, which is now whitish. The tubercles on the prothoracic segment are black, and of the same size as those on the abdominal segments, the latter (dorsal ones) being now about one half as long and large as those on the 2d and 3d thoracic segments; the single median dorsal one on the 8th segment being a little thicker, and colored sulphur-yellow (Riley), like those on the 2d and 3d thoracic segments.*

The curved black line is slenderer than in Stage III. All the legs, both thoracic and abdominal, are pale yellowish.

Stage V. and last. — Length 45–50 mm. In its final shape, the body is cylindrical, tapering towards each end, and not so stout and thick as in *Platysamia*, or *Telea*, or *Actias*, or *Attacus*, and the tubercles are smaller, smoother, and without the conspicuous large spines present in the genera named, while the dorsal abdominal tubercles are smaller than in any other genus of *Attacinae* known to us. In its larval characters the genus is the last and most specialized of a series beginning with *Saturnia* (*S. carpini*) and including *Platysamia* and *Samia*.

The head is small, being a little less than one half as thick as the body, and now is without any black spots. The black dorsal prothoracic and abdominal tubercles *are much shorter than in Stage IV.* The dorsal prothoracic ones are mere black spots, not even rising into low warts; the two lateral ones on each side are much larger than the rudimentary dorsal ones, rising into low conical shining black tubercles no higher than wide. The homologous lateral tubercles on thoracic segments 2 and 3 are larger and more prominent than those on abdominal segments 1 to 7. The rudimentary black dorsal tubercles on abdominal segments 1 to 7 are low rounded conical shining black bosses, which are transversely oval at base, and not so high as wide. The four dorsal 2d and 3d thoracic tubercles, together with the single median one on the 8th abdominal segment, are all of the same size seen sideways, but the last named tubercle seen from in front or behind is thicker, owing to its double origin. The two dorsal ones on the 9th abdominal segment are rather high, being long, conical, but no higher than the median single one on the 8th segment. All the legs are yellowish; each of the middle abdominal legs with a black dot in the middle of the outer side.

Professor Riley has briefly described and in part figured in his Fourth Missouri Report (p. 121) the five stages of this larva; and my material confirms his description. Mr. Dyar, however, claims that from his observations there are but four stages. For the colors, since we have not yet seen the living larva, we must quote from Riley, who states that in the fifth stage “the appearance is totally changed; the body is of a most delicate bluish white, with a faint pruinescence.” Further on he says: “As this worm acquires its full growth, the pruinescence mentioned above disappears, and it acquires a more greenish cast, except around the base of the tubercles, where there is a more decided blue annulation.” In *Psyche* for June, 1891, M. Beutenmüller gives a detailed description of *six* stages, *five* moults. His fifth and sixth stages appear to be the same as our fifth.

THE LIFE HISTORY OF CALLOSAMIA ANGULIFERA (Walk.).

The larvæ hatched on July 6 and 7 from eggs kindly sent me by Miss Morton, and fed on the leaves of the tulip tree, Stages II. to IV., are described from Mr. Bridgham's colored figures. Miss Caroline G. Soule describes the five stages in *Psyche*, Vol. V. p. 260.

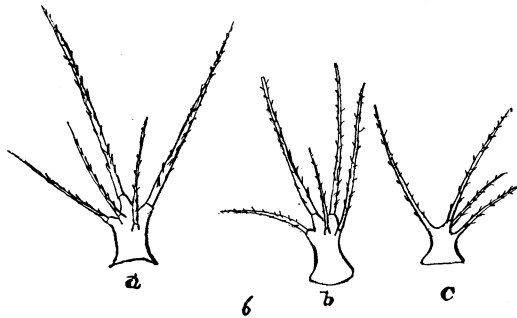
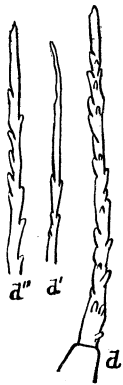
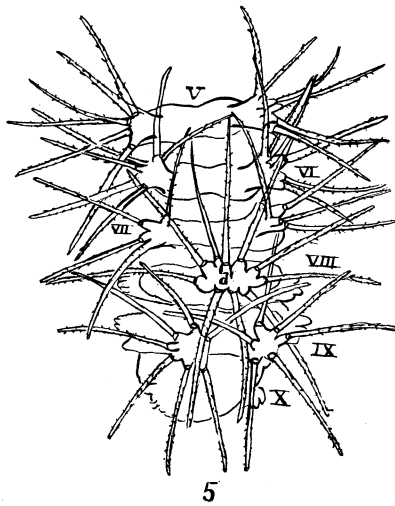
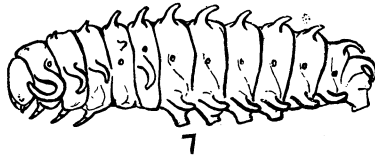
Egg. — Of the same shape and color as those of *C. promethea*, though slightly smaller, while the polygonal markings appear to be even fainter than in *C. promethea*.

Freshly hatched Larva. — Length 4 mm. The head is black, with two lunate ochreous yellow spots on the vertex, while in front, on the middle, is a transverse, pale parchment-colored stripe, and in front of this stripe is a transverse clypeal line of the same pale hue. The body is pale ochreous yellow, and the hairs appear to be of the same color; the two faint transverse lines on each segment being nearly obsolete, so that in some specimens they are not apparent, and the body does not appear to be striped with black, as is so plainly the case in *C. promethea*.

Compared with *C. promethea* of the same stage, the larvæ of the present species are rather smaller, and differ decidedly, the body being much paler, and not heavily striped with black, the transverse black bands, so broad and deep black in *C. promethea*, being much narrower, very much fainter, and often nearly obsolete; also all the tubercles and hairs, except those on the prothoracic and sometimes the 10th abdominal segments are pale yellowish, like the body. The tubercles and setæ on the prothoracic segment are not so dark as in *C. promethea*. The upper pale stripe on the head is a little narrower than in *C. promethea*. The black stripes on the last three abdominal segments are somewhat heavier than those in front. The tubercles on the 9th abdominal segment and the end of the anal or 10th segment may be dusky, while the dark stripes on the segments in front may be entirely wanting.

There is little difficulty in separating the larvæ of the two species at the first stage. It is noteworthy that the colors of the dorsal tubercles are not so much differentiated as in *C. promethea*, or they are in a degenerate stage; the dorsal tubercles of the 2d and 3d and the 1st and 7th to 9th abdominal segments are not dark, as in *C. promethea*, but like those on segments 2-6. The dorsal tubercles are a little slenderer, and the setæ or hairs rather longer, than in *C. promethea*. The tubercles have the same number of setæ as in *C. promethea*, the single one on the 8th abdominal segment having ten setæ, and being distinctly

PLATE II.



ARMATURE OF ATTACINE CATERPILLARS.

divided into halves. There is no black patch on the side of the anal legs, it being well marked in *C. promethea*, and the thoracic feet are considerably paler.

This stage was drawn at Providence, July 8; the 2d, July 13; the 3d, July 15; the 4th, July 19; the 5th, July 26; the larva becoming fully grown August 1.

Figure 5 (Plate II.). The last six abdominal segments (V.-X.) of *C. angulifera*, which should be compared with the camera drawing of the same parts in *C. promethea* to show how different the shapes of the tubercles are, the setæ also differing in the two species at the same stage. The setæ on the suranal plate have not been drawn. The setæ are transparent. *d'*, homologue of the "caudal spine" of Sphingidæ. *d*, a seta enlarged.

Stage II. — Length 8 mm. The body is now longer in proportion than before, and the head is now no wider than the body. The head is black, and striped with whitish yellow, the shape and width of the pale stripes nearly as in Stage I. The prothoracic segment has black dorsal tubercles, and the black transverse dorsal band is divided into two patches, situated behind the tubercles. The tubercles are now shorter than before, with shorter bristles, and those on the 2d and 3d thoracic, and the 1st, 8th, and 9th abdominal segments, are slightly, but not very noticeably, larger than before. The larva differs markedly from that of *C. promethea* of this stage in the faint, narrow transverse stripes, those of *C. promethea* being still heavy and dark. There is no curved black spot on the side of the anal legs; the thoracic legs are much paler than in *C. promethea*. The body is greenish yellow, while the ground color of *C. promethea* is more of a whitish hue. Only the two last abdominal tubercles (on 10th segment) are dusky. (The figures of Mr. Bridgman agree with Miss Soule's description.)

Stage II. — Length 12 mm. The head now differs in being less black, the pale bands being wider, and there are two white spots on the vertex, one on each side. The body is pale straw yellow, more distinctly banded with black than before, the two heaviest and broadest bands being on the hinder edges of the prothoracic and the 8th and 9th abdominal segments, while the suranal plate is blacker than before, with a lateral black line. On the other segments, the black bands (two to each segment) are confined to the back, and do not extend down the sides. All the tubercles from the 2d thoracic to and including the 9th abdominal ones are yellowish.

At the end of this stage, length 18 mm. The body is rather thicker

than before, and whiter yellow; the head with more white, especially on the vertex, and the white stripe across the middle is rather wider. The 2d and 3d thoracic, 1st, 8th, and 9th abdominal dorsal tubercles are not distinctly larger than the others, and all are paler. The black stripes are nearly as before, but perhaps not quite so heavy. The suranal plate is not so black as before, but with two black spots; and *on the side of the anal plate is a black elongated patch.*

Stage IV.—Length 34–35 mm. The characters of the fully grown larva are now nearly attained. The head is large, three fourths as wide as the body, pale lemon-greenish, with six black dots, two below, and one above. The two dorsal prothoracic tubercles yellowish; the lateral ones black. The two dorsal tubercles on the 2d and 3d thoracic segments are now high, large, and with obsolete spines, red, with a black base or ring (Miss Soule says, “black at base, ringed with yellow, orange at tips, smooth”). The single one on the 8th abdominal segment is ringed with black at the base, and beyond yellow; it is slightly smaller than those on the thoracic segments. All the other dorsal as well as lateral tubercles are now reduced to low small black rudimentary tubercles. In this stage it differs from that of *C. promethea* of the same stage in the much shorter black tubercles on the 2d to 7th abdominal segments; and in the dorsal tubercles on the 2d and 3d thoracic segments being reddish, instead of yellowish. The curved horseshoe-shaped black line on the side of the anal legs is the same as in *C. promethea*. The “yellow stigmatal ridge” noticed by Miss Soule is shown in Bridgham’s figure.

Full-grown Larva.—Length 68 mm. On comparing a blown specimen of *C. angulifera* with one of *C. promethea* the former differs in the following particulars. The head is slightly larger, without the two black dots in front and the lateral dot, and without the broad black stripe extending in *C. promethea* from each side of the base of the labrum upward, and ending on the side of the head below the lateral dot. The four dorsal black spots on the prothoracic segment are wanting in *C. angulifera*, and the short lateral tubercles are not colored black as in *C. promethea*, while the tubercles themselves are much smaller and less prominent. The four dorsal tubercles (two on the 2d and two on the 3d thoracic segment) are decidedly smaller and slenderer than in *C. promethea*; the tips are black where those of *C. promethea* are yellow, and the black ring around the base is narrower than in *C. promethea*. The two lateral small black tubercles on each of these segments are wanting, and all traces of them have nearly

or quite vanished. Of the dorsal ones I can with difficulty, by means of a good lens, find faint traces, they are so nearly effaced.*

There are in *C. angulifera* no black spots on the base of the four pairs of middle abdominal legs, and there is a black ring only on the lower side of the anal legs, as in *C. promethea*. The suranal plate has two transverse linear black spots on the ends, but none of the other black markings of *C. promethea*. It wants the pair of triangular black sternal spots situated in front of each pair of thoracic legs of *C. promethea*. The median dorsal horn on the 8th abdominal segment is black at the base and tip. The two dorsal black tubercles on the 9th segment, and the lateral ones, are wanting, though they are conspicuous in *C. promethea*.

C. angulifera is much duller in color and much less ornamented, with shorter, less conspicuous tubercles, and all, both dorsal and lateral, on abdominal segments 1 to 7 are wanting. It seems to be a form which may be regarded as having originated later than *C. promethea*, and which has diverged from it, and it seems to be a species which has directly evolved from the stem-form *promethea*.

RECAPITULATION OF THE MORE SALIENT ONTOGENETIC FEATURES OF CALLOSAMIA.

A. *Congenital Features.*

1. Hatched with heavy black transverse bands on a yellow body, and the head black, banded with yellow; the bristles moderately long; thus the larva is already a rather conspicuous object.

2. The dorsal thoracic tubercles already differentiated in size and color from those on abdominal segments 1 to 7. The differences between the freshly hatched larva and the last stage very marked; more so than in *Platysamia* or *Samia*.

B. *Evolution of later Adaptational Features.*

1. In Stage II. the body becomes paler, and thus the black bands more conspicuous. The 2d and 3d thoracic dorsal tubercles and those on abdominal segments 1 to 8 are now all yellowish, and of the same size.

* These tubercles have evidently disappeared owing to disuse. What there is in its habits to bring this about is a matter of conjecture; this form is only known to feed on the tulip tree, and this may be a case of arboreal selection; the change of food plant, together with possibly the abundance of food, this tree having but few species of larvæ feeding on it, may have had something to do with the abolition of the tubercles.

2. Disappearance in Stage III. of the transverse black bands. The abdominal tubercles all become blackish.

3. In Stage IV. the head becomes yellow, being less conspicuously marked, and the dorsal abdominal tubercles are about half as long and large as those on the 2d and 3d thoracic segments.

4. The body becomes in the last stage much smoother than before, the dorsal prothoracic and abdominal tubercles being much shorter than in Stage IV. This reduction of size and inconspicuousness of the dorsal abdominal tubercles is carried out to excess in *C. angulifera*, where they become obsolete, and the larva is simply a large green caterpillar with inconspicuous markings, and simply protected by its green color, like the majority of lepidopterous larvæ; not being so strikingly marked as in the fully fed *Samia cynthia*.

THE LIFE HISTORY OF SAMIA CYNTHIA (Drury).

The eggs were received from Mr. H. Meeske. The larvæ were at first fed on the leaves of the ailanthus, but when transferred to Brunswick, Maine, ate freely of the wild plum.

The Egg. — Regularly oval-cylindrical, dull chalky white; the surface of the shell finely pitted, but not arranged in wavy rows as in *P. cecropia*; the pits under a half-inch objective are near together and slightly polygonal, and their walls project as little bosses on the inside of the shell. Length 2 mm., thickness 1.4 mm.

Larva, Stage I. — Hatched June 11. Described one day after hatching. Length 4-5 mm. Head rather large, as wide as the prothoracic segment. The body gradually tapers from the head to the tail, and is of a pale greenish yellow, the head dark chestnut, with a pale greenish clypeus and labrum. The prothoracic segment is broad and somewhat flattened above, with a dark chestnut-colored chitinous plate or squarish patch on each side, sometimes appearing as widely separated by a pale greenish yellow clear median dorsal space; with four dorsal and two lateral black tubercles; of the dorsal ones the two in the middle are slightly larger than those outside, and larger than the lateral ones; they are also connected at their base by a slight ridge. All the tubercles are much alike on all the segments, bearing from 5 to 7 setæ, those on abdominal segments 5 to 7 scarcely smaller than those on the thoracic. The hairs or bristles are whitish, or rather colorless, 4 or 5 to 7 on each dorsal tubercle; they are slender, not stiff or thickened at base, and are spinulated, the spinules short and acute; under a half-inch objective they appear, not bulbous, but tapering, and being transparent may be glandular.

The single median tubercle on the 8th abdominal segment is sometimes nearly twice as large as the others on the same segment, and is double, being broader than long, bearing four bristles on each side.

There are two setiferous tubercles on the 9th abdominal segment, and, as generally in the group, two short but large ones on the 10th, being situated on the front edge of the suranal plate, and bearing each eight bristles. All the tubercles on the body are jet-black.

The spiracles are pale, and inconspicuous. The thoracic feet bear three lancet-shaped tenant hairs, but they are a little wider than those of *P. cecropia*. The abdominal feet bear fourteen crotchets.

Before the first moult the larvæ increase in size and length (7-8 mm.), becoming much fuller, swollen out with food; the body, however, is smooth, the segments not being swollen; it is bright straw-yellow; the spines are not so long as before, and the bristles are considerably shorter. *A dorsal row of dark spots is present.*

Before a change of skin the larva rests immovably for several hours, the membrane in front of the prothoracic segment being swollen between the head and the front edge of the segment, and the head, now appearing to be very small in proportion to the swollen prothoracic segment is held downward, while the thoracic feet are stretched forward. In moulting it leaves behind it only a small mass of crumpled skin, as the cuticle is so thin.

Figure 6 (Plate II.), *a*, dorsal tubercle on 2d thoracic segment; *b*, the same on the 3d thoracic segment; *c*, a subdorsal tubercle of the 7th abdominal segment; *d*, a seta; *d'*, *d''*, ends of two others. All Stage I. Drawn with the camera.

Stage II. — One had just moulted, June 17. The body was all yellow except the dorsal and two lateral rows of black spots between the rows of tubercles, there being two spots in each row on each segment. All the tubercles are now amber-yellow, and the hairs are pale.

An individual was noticed to increase in length soon after ecdysis. It was observed at 4.20 P. M. In about twenty minutes or half an hour after moulting, when it is 9 to 10 mm. long, the tubercles on the side, especially those in front, begin to turn dark, the thoracic ones first changing color. In about an hour an obscure broad dusky band crossing the head appears; in fifty minutes or an hour, the thoracic legs have turned blackish, and by this time the creature begins to eat, this species feeding well in confinement. In an hour and a half the lower lateral (infraspinal) row of tubercles and those on the 10th abdominal segment had turned black, but the upper lateral and dorsal ones were still pale. By 6.30 P. M. the others, both dorsal and lateral,

had become dark at the tips, but the hairs were still pale. About a day later, i. e. at 5 p. m., the tips of the tubercles only were dark, the bases being still pale yellow as before.

This stage differs but little from the first, chiefly in the *pale honey-yellowish head*; there are as yet no differences in the size of the dorsal tubercles, though they are in this stage *pale yellowish at the base*, where before they were black throughout.

Stage III. — They moulted again, June 22–23. Length 14–15 mm. The body is of the same yellow hue as before, the tubercles at first being all yellow. The lateral ones are the first to turn dark. The head is pale yellow, concolorous with the body.

In the preceding stage, on each abdominal segment there is an upright faint short blackish stripe behind the spiracle; in the present stage there is a jet-black stripe, which is somewhat curved or excavated on the front edge; there is none on the prothoracic segment, and the stripe is represented on the 2d and 3d thoracic segments by an irregular black rounded dot. At the base of the thoracic legs is a black dot, not present at the base of the abdominal legs. The tubercles are nearly of the same shape and relative size as in Stage II., *but the six dorsal and four last abdominal (the dorsal ones on 9th and 10th segments) are slightly larger than the other abdominal ones*, while the spiracles are larger than before and black; the other black marks are as before.

Stage IV. — One moulted again the morning of July 1. Length 15–16 mm., one 20 mm. and eventually becoming 25 mm. When observed an hour or two after casting its skin, the body as before was pale lemon-yellow; the tubercles of the same color as before, i. e. pale greenish yellow, except those of the lower lateral row which are black on the trunk, but with the head or end and the spines light greenish yellow. The dorsal and two lateral rows of black spots are as before. The head and upper side of the prothoracic segments are shining honey-yellow, *as is also the 9th and 10th abdominal segments, while the body is covered with a whitish mealy bloom.*

The larvæ, which were reared in Brunswick, Maine, from eggs laid in Brooklyn, seem to feed sparingly and to grow slowly, and were fed at first with ailanthus, and afterwards with wild plum. They became before moulting again very white, *the bloom being thick and powdery, so that the honey-yellow head and prothoracic plate, with the suranal plate, together with the sides of the anal legs and upper part of the 9th abdominal segment, contrast with the color of the body.*

In this stage the two anterior setiferous tubercles on the suranal plate are still well developed, as are also their bristles.

Stage V.—Moulted July 15–18. Length 40 mm. It differs from the preceding stage in the rarely beautiful *pale turquoise-blue edging on the edge of the suranal plate and anal legs, and in the pale bluish tint on the ends of all the tubercles, and at the base of the middle abdominal legs.*

The head is lemon-yellow as before, about one half as thick as the body, and is bluish on the region of the eyes. The prothoracic segment is lemon-yellow, edged with pale blue, while the tubercles are of a beautiful pale turquoise tint. The tubercles are still long and slender, those of the thoracic and last two segments scarcely larger than the others.

In this genus the tubercles are remarkably long, with short, small, pale radiating bristles, much shorter and slighter than in *Platysamia*.

The suranal plate also in Stage V. *bears two low bosses without bristles* (only their rudiments), while in *P. cecropia* these tubercles with their bristles are well developed; it also differs in the black spots of the last stage.

Those of the dorsal and subdorsal rows are pale whitish green at base, passing towards the end into pale turquoise-blue. The infra-spiracular row of tubercles are ringed with black at the base. The black spots on the body are as in the previous stages. The thoracic and abdominal legs are lemon-yellow, the latter pale bluish at base and on the planta. The suranal plate and dorsal region of the 9th segment are lemon-yellow, the thickened much swollen edge of the suranal plate is turquoise-blue, including the tubercles, and the edge of the anal legs is of the same tint, the blue suddenly expanding on the lower side above the crotchets.

In this stage the body in general is turquoise bluish white, rather than pure white or slightly yellowish white, as in Stage III.

August 20th one spun a cocoon, and the others stopped growing, perhaps partly on account of the cooler climate than their parents had experienced, though the season of 1890 was a warm one for Maine.

By the larval characters this Chinese or Eastern Asiatic genus is much more closely allied to *Platysamia* than to *Attacus*, though the imago perhaps has more of the habit and general form and appearance of *Attacus*. It differs from *Platysamia* in the rather slenderer body, the decidedly longer tubercles, and the slighter, shorter bristles arising from them, and in coloration by the pale lemon-yellow skin, with the conspicuous black spots, and the beautiful turquoise-blue markings, as well as the peculiar soft white bloom on the skin. How far this style of ornamentation adapts it to its native Asiatic food plant we do not know.

Recapitulation of the more Salient Ontogenetic Features.

A. Congenital Features.

1. Hatched with large, well developed setiferous tubercles; but the bristles not bulbous in Stage I.

2. The body pale, but the tubercles dark, and besides these inter-tubercular conspicuous black spots are present in Stages I. to V.

3. The homologue of the "caudal horn" is double, bearing four bristles on each side.

The difference between the larva of the first stage and the last, unusually slight compared with *Platysamia* and *Callosamia*.

B. Evolution of later Adaptational Features.

1. The tubercles become pale at tip in Stage III., and those of the two dorsal rows of the thoracic and last two abdominal segments become slightly larger than those of abdominal segments 1 to 7, in Stage III.

2. Differences in coloration appear in Stage IV., the head, prothoracic and last two abdominal segments being honey-yellow, thus contrasting with the whitish body, with its whitish bloom, which also appears in this stage.

3. Farther changes in color appear in the last stage, the ends of all the tubercles becoming pale bluish, and the edges of the suranal plate and anal legs being a rich turquoise-blue.

4. In the last stage a very slight difference in the size and shape of the thoracic and the last abdominal tubercle.

5. The tubercles on the suranal plate become reduced to low bosses, without bristles. Thus *Samia cynthia* is a decided step in advance of *Platysamia*, and appears to be a later formed genus.

Comparison between the Larva of Samia and Callosamia.—The fully fed larva of *Samia cynthia* is in the shape of the head and body, and in the shape of the tubercles with which the latter is armed, more allied to *Callosamia* than to *Attacus*, although the imago is perhaps as near the latter genus as to *Callosamia*. The head of the larva of *Samia* is almost identical with that of *Callosamia*. The nearly obsolescent tubercles on the prothoracic segment have about the same degree of degeneration in *Samia* as in *Callosamia*, but the former differs in the fact that the lateral tubercles in all three thoracic segments are well developed, and end in a head armed with four spines, as in *Platysamia* (*P. cecropia*), while the tubercles are as well de-

veloped on the abdominal segments as on the thoracic. The thoracic tubercles also are no more differentiated than the abdominal ones. *Samia* also differs from *Callosamia* in the twelve rows of black spots along the body. The larva of *Samia* is thus seen to be intermediate between *Platysamia* and *Callosamia*, but the moth is apparently intermediate between *Callosamia* (*C. angulifera*) and *Attacus*.

The head and the shape and size of the body of the larva are like those of *Callosamia*, but in its secondary adaptive generic characters it retains a resemblance to *Platysamia*. In a systematic classification, then, we had better adopt the imaginal characters rather than the larval, the latter being so much more plastic and more readily influenced by changes in the mode of life and by differences in the food. In its earliest larval stages, the insect is certainly more like *Platysamia cecropia* than *Callosamia*, but still even in these stages *Samia* is more advanced than *Platysamia*, which in its earliest larval stages, especially in the possession of long bristles arising from the short tubercles, intergrades with or is closely allied to the fully grown larva of *Saturnia carpini*; and in the imaginal characters *Platysamia* is nearer the ancestral form *Saturnia* (in the restricted sense) than to any of the other *Attaci*. If we do as we should do in locating *Samia* in its proper taxonomic position, we shall not err greatly in placing *Samia* much above *Cecropia*, and on the whole near *Attacus*.

LARVA OF *ATTACUS* SP. (POSSIBLY *A. SPLENDIDUS* DeB.).

The larva of which I give the following description was collected at Socorro, Arizona, September 9, 1874, by Wheeler's Expedition. The single specimen was in alcohol. It is probably about half grown. (Plate II. Figure 7.)

Length 25 mm. Head rather large, slightly more than one half as wide as the body when it is thickest; it is of a chestnut color, smooth, not hairy. The body is moderately long and quite thick and fleshy, tapering rather rapidly behind. The prothoracic segment is granulated above, but with no tubercles; on each side, however, is a remarkably long fleshy tubercle or process, which hangs down and curls back like a ram's horn, and is finely spinulose; it is about as long as the segment is thick, and is situated exactly in front of the spiracle of the same segment. On each of the 2d and 3d thoracic segments is a pair of short thick tubercles, those on the 3d a little longer than those on the 2d segment. On each side of these seg-

ments is a long curled tubercle similar to those in front, but only a little more than one half as long; those on the 3d segment are shorter and thicker at the end, and a little more than one half as long as those on the segment in front. On each of abdominal segments 1 to 9 is a pair of similar tubercles or processes which increase in size and length from segments 4 to 9, those on 7 to 9 being of nearly the same size. On the side of each of abdominal segments 2 to 8, situated far below the spiracles and just above the legs where present, are similar horn-like processes, but which are longer than the dorsal ones on the 2d abdominal segment, whereas on segments 3 to 8 they are about the same size and length. All these processes are provided with short hairs. It is probable that some or all of them are more or less erectile.

This species is allied to the larva of *Attacus atlas* Linn., as figured by Horsfield and Moore in their Catalogue of Lepidopterous Insects, II., Pl. XX. Fig. 2. It differs, however, from the full-grown larva of that Asiatic species in the dorsal abdominal processes being shorter, and the lateral abdominal ones being much longer, especially on segments 4 to 9, while the thoracic ones are longer, especially the first pair next to the head. But the larva is of the same general shape, and undoubtedly is a true *Attacus*.

Attacus appears to be the only genus possessing these remarkably soft, long fleshy processes, which remind us of those of the *Cochliopod Phobetron*.

THE LIFE HISTORY OF *TELEA POLYPHEMUS* (Cramer).

The larvæ, usually feeding on the oak, have been found on the chestnut, and in Maine on the beech. Although so often raised, a full life history of this fine insect has not yet been published.

Egg. — Regularly oval-cylindrical, each end alike; flattened at each pole; surface chalky white, with a very broad, conspicuous dark brown band. Under a lens, the surface of the shell is seen to be finely pitted or granulated; under a half-inch objective, the surface is seen to be covered with round shallow depressions bordered with a well marked rim; these orbicular areas do not touch each other, there being quite wide spaces between them; they are arranged obliquely. Length of egg 2.6 mm., breadth 2.2 mm.

Larva, Stage I. — Hatched June 12. (Described when 20–24 hours old.)

The brood hatches all at once, or nearly so. Length 5 to 6 mm.

The head is large and full, rounded as usual in the family; as wide as or slightly wider than the body, i. e. the prothoracic segment, not taking into account the lateral tubercles. It is deep bright brick-red; the labrum, antennæ, and jaws yellowish. The body gradually tapers backwards from the head.

The body is of a soft, pale greenish yellow; the tubercles pale yellowish, contrasting with the color of the body. The prothoracic segment flares in front, the edge turning up and bearing two large dorsal tubercles which are double. The prothoracic tubercles are very prominent, projecting on each side, and are about twice as large as the 2d and 3d thoracic ones, and bear twelve bristles. These tubercles and those of the same series on the 9th abdominal segment are much larger than the intermediate ones. There is a slight differentiation in size and color of the dorsal tubercles, those of the thoracic and 9th abdominal segments being of the same size, and larger than those on abdominal segments 1 to 7, and also of a deeper yellow shade. The bristles are pale, those on all the thoracic tubercles, dorsal and lateral, a little darker than those on the abdominal segments, and darker at the tips. They are but little longer than the tubercles, and there are about six on each abdominal tubercle. Under a half-inch objective the bristles are seen to be not only docked at the tip, but the latter is slightly but distinctly swollen or bulbous, and sometimes containing an oval mass of the coagulated secretion.

The median dorsal tubercle on the 8th abdominal segment is as large as those on the thoracic segments; it is twice as wide as long at the base, *and is more deeply divided than in any other of our Attaci known*, very plainly showing its origin from two originally separate dorsal tubercles; *each fork is well developed, being about as long as thick*, and each bearing from 4 to 5 bristles.

All the tubercles of the 9th segment are very large, about as large as those of the thoracic segments. The suranal plate is large, nearly equilaterally triangular, and bears near the apex two tubercles, each of which gives rise to eight bristles; they are smaller in proportion, and nearer together, than those of *C. promethea*.

The prothoracic segment is pale yellowish in front, chestnut-colored behind, becoming blackish on the sides low down. At the base of the lateral prothoracic tubercles are three black rings. On the side of each abdominal segment 1 to 8 is *a pair of parallel black slashes*, situated between each of the upper and lower lateral tubercles; on the 2d and 3d thoracic segments they meet on the middle of the back as chestnut-colored stripes. On each side of the 9th abdominal segment

is a large pale yellowish amber tubercle.* In some individuals all the tubercles on the body are amber-yellow.

The thoracic and abdominal legs are pale greenish, with no markings. The thoracic feet bear near the unguis the usual three tenant hairs, which are long-lanceolate, and moderately broad. The number of crotchets on the abdominal feet is twenty-four, larger by eight than in the other *Attacidae* observed.

June 17, they had become larger, fuller, and from 9 to 10 mm. in length. The body is of a beautiful soft glaucous green, the tubercles yellowish, those on the prothoracic segment tinged with reddish; the black-brown slashes on the sides of the body are still present, but narrower. They are voracious feeders.

June 19, at Providence. (Like Mr. Bridgham's second drawing, Stage II.) I have not seen them cast their skins, though they must have done so. They are now 11 mm. long. They still retain the black slashes. All the tubercles are yellowish; the body being of a beautiful glaucous green. In some individuals the lateral prothoracic tubercles are reddish.

Figure 8 (Plate III.). Dorsal view of the 8th to 10th abdominal segments of the larva in Stage I., showing the double tubercle (d') on the 8th segment (VIII.), and the two separate dorsal tubercles (d) on the 9th segment (IX.), with the two subdorsal tubercles of this segment (sd), together with the suranal plate (X.) and its armature.

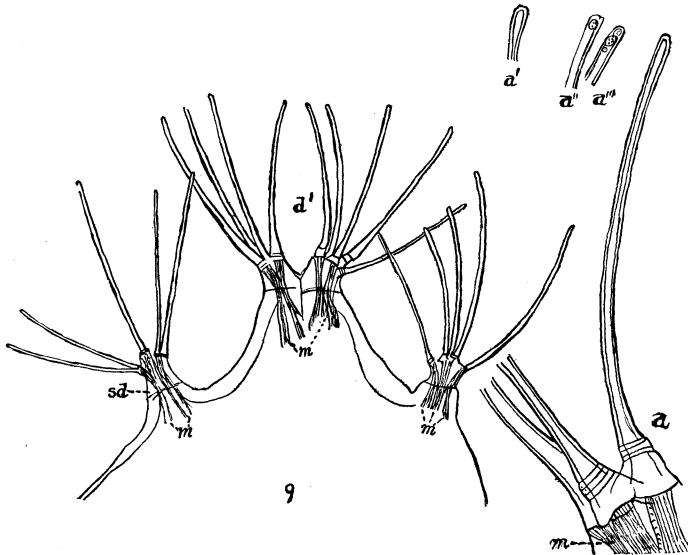
Figure 9. A view of the double dorsal tubercle (d') of the same stage, showing the median line of union of what in embryonic life were probably separate dorsal tubercles, like those on the segments in front and behind; m , the muscles moving the setæ; sd , the subdorsal tubercles; m , the retractor muscles of the tubercle; a , one of the setæ, much enlarged, with the bases of two others; a' , a'' , a''' , ends of other setæ, containing at the end globules of the medullary fluid. The setæ are seen to be smooth, without spinules of any sort. It is to be observed that in the double dorsal tubercle there are only four setæ on one side and five on the other, but five must be the normal number, and the number usual in the larvæ of the group at this stage.

Stage II.—June 23. Length 14 to 15 mm. They have most probably moulted, *the lateral pair of upright parallel slashes having*

* In *A. luna* the suranal plate is triangular, but slightly shorter than in *T. polyphemus*, the two tubercles are wider apart, not so near the end of the plate, and are much lower and flatter, while those of *T. polyphemus* are quite high and slender, papilliform.



8



9

ARMATURE OF ATTACINE CATERPILLARS.

disappeared. The spiracles are now black and very distinct. The tubercles are deep orange at the end, the dorsal ones bearing mostly blackish bristles, with one or two white ones, those on the side of the body being pale; the lateral tubercles are orange, all the prothoracic tubercles deep orange, and the segment itself is edged with greenish yellow orange. The thoracic legs are deep orange; the abdominal legs green, tipped at the planta with yellow orange.

There is now a *lateral curved white band connecting the lateral tubercle on the 9th segment, with the corresponding one on the suranal plate.* Along the back and between the dorsal tubercles the skin has a soft glaucous bloom. The head is dark chestnut-red, as before.

In this stage the larvæ frequently assume a sphinx-like attitude, while those of *P. cecropia* and *S. cynthia* do not seem to, but these two species are in general more active, trying to escape from confinement.

Stage III. — Moulded July 1. Length 20 to 25 mm. The color of the head and tint of the body as before. The larva now differs in *the segments being more convex and angular*, or in transverse section somewhat square, somewhat as in the last stage. All the tubercles are alike in being pea-green at base, becoming deep reddish orange at the end, and bearing partly black and partly white spines or bristles, except the two median short tubercles on the prothoracic segment, which are yellow, and concolorous with the yellow margin of the whole segment. There are more white bristles on the abdominal than on the thoracic segments.

The spiracles are unusually narrow, being vertically almost linear, and orange-red, i. e. concolorous with the tubercles at the end, and now directly behind them is the *more or less distinct yellowish lateral slightly oblique stripe connecting the lateral tubercles of the lower and of the upper row*, and which touches each spiracle. (These were indicated, though less distinctly, in Stage II.)

The beautiful pale purplish whitish band or edging on the suranal plate, and connecting the two lower lateral tubercles of the 9th abdominal segment, is *now very distinct*; above, it is edged within with a *linear brownish line forming a V*, which does not reach the tubercles on either side, in fact only extends about half-way from the end of the suranal plate to the base. The median dorsal tubercle on the 8th abdominal segment is still plainly double, and larger than any of the others.

We thus have assumed in this stage the characters of the larva in its final stage.

The excellent differential characters separating this genus from other Attacinae are now defined, and the same will apply to the larvæ of the third stage of *Platysamia*, *Callosamia*, and *Actias*, as well as *Samia* (*Philosamia*).

The following descriptions apply to two individuals specially observed during this stage.

One (A) in Stage II. was seen to cast its skin, July 5, at 11.15 to 11.30 A. M. The head was pale greenish yellow, like a peach, but without the reddish pink tinge. (*A. luna* appears to permanently retain the greenish tint.) The thoracic legs are greenish. All the tubercles are lemon-yellow, the short bristles on the thoracic tubercles black, those on the abdominal segments turning black. The long whip-like hairs are white. The V-shaped band on the edge of the suranal plate is a deep labradorite-azure. The lateral stripes are not yet very distinct. The spiracles are deep orange.

At 12.30 P. M. the head had turned almost chestnut-brown, and by 1 P. M. was of the normal dark chestnut-red hue.

Before casting its skin, it spins a thin carpet of silk threads, to which it clings with its crotchets while in the process of exuviation.

Another caterpillar (B) in Stage II. about moulting was first noticed at 11.30 A. M. The head was small, about half as large as in the next stage, pressed forward; the prothoracic segment above has a large yellow patch extending back to the next segment. The region is about half as wide as the whole segment, being that portion situated behind the two middle dorsal tubercles, and the brown membrane or neck connecting the head and the succeeding segment is tense. Now all the tubercles are deep orange-red, while there are no fine white hairs arising from the thoracic tubercles, and those arising from the abdominal tubercles are much shorter, nearly one half, than in the next moult (A). It fastened its crochets in the silk carpet it had spun previous to the beginning of the process of exuviation, so that the convulsive movements of the head and thoracic segments may not cause it to fall over while in the act of throwing off the old skin. The head is about one third, and almost one half, larger after moulting than before.

Now and then before the skin splits, and is cast off, the larva was observed to make a series of convulsive movements of the head and thoracic region.

It finally cast its skin between two and three o'clock P. M., and this individual looked like A when I first saw it.

This larva also was observed resting with its head and thoracic

region raised in a sphinx-like attitude, jerking its head sideways when disturbed. The pale chestnut face forms, with the folded thoracic feet, a continuous patch of color, of the same tint as that of the leaf buds, and the base of the leafstalks of the oak. In eating I do not see that the maxillæ and labium are of any service, but on the contrary seem to be in the way. Both are in lepidopterous larvæ rudimentary, and the labium in the main functions as a spinning organ.

Stage IV. — Moulded July 11–12. Length 40 to 45 mm. This differs but little from Stage III. The head is of the same color as in the three previous stages, and about half as wide as the body. The segments are rather more angular above than before. The prothoracic segment is yellow in front; the tubercles are small, and of the same yellow tint. All the other tubercles, both dorsal and lateral, are orange-red; *the dorsal tubercles have on the outside of the base, and extending nearly half-way up, a bright spot with a decided pearly color and lustre*; this spot is wanting on the infraspicular tubercles. Most of the bristles are black broadly ringed with white, or white at the base, and on the distal half. The median dorsal tubercle on the 8th abdominal segment is still distinctly seen to be double, being bilobed at the end, each lobe or subtubercle bearing about four white setæ, one of them black.

Along the sides of the body project long white hairs. The spiracles are orange-brown, as before. The suranal plate is edged with flesh-pink, and the anal legs are bordered behind with the same smooth flesh-pink margin. The thoracic legs are reddish amber, black at their ends. The middle abdominal legs are green; the plantæ livid purplish; above the planta is a dark patch, bordered above with yellowish.

Stage V. — Moulded July 22–24. Length 60 mm. It now scarcely differs from the preceding stage. The silver tint on the outside of the base of the dorsal and subdorsal tubercles, and on the upper side of the base of the infraspicular tubercles, is a little more distinct than in Stage IV., as in the latter stage the 2d and 3d thoracic dorsal and subdorsal tubercles are more orange than those on the abdomen, which are deep coral-red; but in some of Stage IV., the thoracic ones are coral-red.

The head is reddish chestnut, and is the same in hue as in Stages I. to IV. The prothoracic segment is edged with yellow, the pale yellowish lateral stripe as in Stages III. and IV. The spiracles are deep orange-red. The segments are now convex and almost angular, more so than in the other native forms of this group, unless we except *A. luna*.

One of this brood began to spin, and had completed the exterior of its cocoon by August 1.

The object of the purplish edging on the suranal plate and anal legs was impressed upon me while observing a large full-fed caterpillar resting by a short leafstalk, the leaf having been broken off so as to be a quarter of an inch long and curved. In color and shape it exactly resembled the purplish edgings of the suranal plate and legs, and thus added to the protective resemblance to a leaf and its stalk.

A fine large *T. polyphemus* was observed at Providence, September 27, on the chestnut. I was struck with the resemblance of the outline of the creature's back — the segments being angular so as to render the body serrate, each tooth-like form of the segment surmounted by a tubercle and long hair — to the serrated edge of the leaf, each of the teeth ending in a long hair. It is not improbable that the ancestors of *Telea*, *Actias*, and others with angular segments, may originally have fed on trees with such serrated leaves, and that later they adopted as their more usual food-plant such trees as the oak, in which the edges of the leaves are either smooth or simply lobed.

Recapitulation of the more Salient Ontogenetic Features.

A. Congenital Features.

1. The setæ (bristles) of Stage I. but little longer than the tubercles, and both truncate and distinctly bulbous at tip.
2. A slight but distinct differentiation in size and color of the dorsal tubercles, those of the 3d thoracic and 9th abdominal segments being of the same size, and larger than those on uromeres 1-7, and of a deeper yellow shade. (Stage I.)
3. The homologue of the "caudal horn" is distinctly double, and more deeply divided than in any other American genera of *Attacinæ*; each fork about as long as thick. (Stage I.)
4. Abdominal legs each with twenty-four crotchets (a larger number by 6 to 8 than in the other genera), Stage I.
5. Each abdominal segment (uromere) with a lateral pair of transverse black slashes in Stage I.
6. The two tubercles in Stage I. on the suranal plate slender, papilli-form, and approximate.

B. Evolution of later Adaptational Characters.

1. The lateral pair of black transverse stripes on each uromere nearly or quite disappear in Stage II.
2. The segments more convex and angular in Stage III.

3. Appearance of a yellowish lateral oblique stripe connecting the lateral tubercles of the lower and upper row, in Stage III.
4. Appearance of the pale purplish edging of the suranal plate and anal legs, in Stage III.
5. Appearance in Stage IV. of the pearly spot on the outside of the dorsal tubercles.

The generic characters are mostly assumed in Stage III.

THE LIFE HISTORY OF *ACTIAS LUNA* (Linn.).

The eggs were received from Mr. James Angus.

Egg. — Oval-cylindrical, somewhat flattened. The shell is thick and tough, dark brown externally, but in places the brown is worn off, leaving a dull, sordid chalky whitish surface; the inside of the shell slightly bluish gray. The surface of the shell is seen under a Tolles triplet to be rough and finely granulated, and under a half-inch objective, the surface is seen to be closely granulated, the pits between the granulations being often confluent; rarely the raised bosses appear to be polygonal. Length 2.1 mm., breadth 1.8 mm.

Larva, Stage I. — Length 6–8 mm. Some were observed hatching out between 11 and 1 o'clock P. M., June 15. Before entirely breaking out of the egg-shell the tubercles on the anterior segments become erect, and the hairs radiate from them, but behind along the 3d thoracic and abdominal segments the tubercles were seen to be soft, and flattened or appressed to the body, and adhering in flaccid bundles. In *P. cecropia*, on the other hand, all the tubercles and bristles are flabby for perhaps half an hour after the creature frees itself from the egg.

One was seen to emerge at 1.15 P. M., and by 1.25 P. M. all the tubercles had become filled out and erect, with stiff radiating bristles.* On hatching, the body is entirely green, except the bands on the head. Some larvæ on hatching are (*a*) entirely yellowish green, while the dorsal hairs are darkish, and the head is twice banded. Others (*b*) have a *very broad blackish lateral band*, enclosing one lateral row of greenish tubercles, the band ending on the 8th abdominal segment, and nearly meeting above. The prothoracic segment is dark on the hinder edge, and the 2d and 3d thoracic and 1st abdominal segments are entirely dark above.

* It is evident that before and at the point of hatching the setæ or bristles are filled with blood, which distends them. While thus distended, the fluid may ooze out of the ends, and thus they may be called glandular hairs. In those which are full and bulbous at the end, the fluid may be retained through Stage I., and in rare cases through the second or even the third stage.

The following description is drawn up from individuals which had been hatched for about a week (May 24–26), and were near the end of this stage. The body was larger, fuller, and less tapering posteriorly than at first. The head is small, about half as wide as the body, rounded, and at rest can be retracted within the prothoracic segment. There is a *transverse dark brown band in front just below the vertex, making two scallops*, and ending on the sides; on each side (below) of the front edge of the clypeus is a dark spot around the base of the antennæ, which sometimes sends a *short line inwards*, as in Mr. Bridgham's figure.

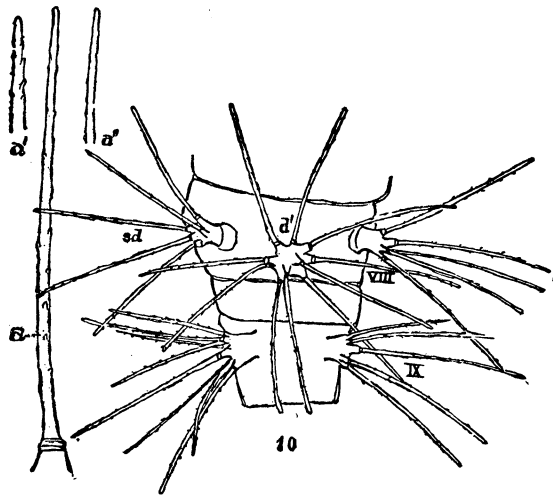
The body is thick, full, cylindrical, each segment, except the prothoracic and last two abdominal ones, with six thick, smooth conical tubercles, those on the sides above the spiracles smaller than those below, and about one half the size of the dorsal ones, and bearing fewer bristles than the others. Prothoracic segment with only four tubercles, the two dorsal ones low, flattened, and small, with about fourteen radiating bristles. The lateral tubercles are like those of the other segments; the rest of the dorsal tubercles are large, full, nearly touching at their base, and bearing about eight to ten bristles, which are one half to one third longer than the tubercles themselves; they radiate and are dark purplish, pale at base, those on the back darker than those arising from the lateral tubercles. *The 2d and 3d thoracic dorsal tubercles are slightly larger than the abdominal ones.* Each of the dorsal abdominal tubercles bears about six bristles. The body is delicate pea-green, nearly like the under side of the *Carya* leaf on which they feed. The tubercles, especially the dorsal ones, are tinged with faint straw or lemon yellow, while the lateral supraspiracular tubercles are greenish, scarcely tinged with yellow.

The bristles are longer in proportion to the tubercle than in the larva of *C. promethea*; most of them are three times and some four to five times as long as the tubercle. The bristles are sparingly and minutely barbed, tapering acutely, but they are clear, and perhaps glandular.

The median dorsal tubercle on the eighth uromere shows traces of its double origin, but they are not so marked as in *C. promethea* and *T. polyphemus*, but more so than in *Platysamia cecropia*. It is much broader than long at base, and on the tip bears five setæ on each side. The ninth uromere bears four tubercles of equal size, which are large and well developed, the lateral ones scarcely smaller than the dorsal ones. The suranal plate is broad and short, more so than in *T. polyphemus*, not tubercled, but bearing two tufts of bristles which are but

a little shorter than those arising from the lateral tubercles of the rest of the body.

The anal legs are large and squarish, as in the group generally ; all the legs, both thoracic and abdominal, are pale green. The abdominal legs bear each twenty crotchets. The three tenant hairs of the thoracic feet are rather longer than usual. The spiracles are slightly chitinous, not colored.



The shape of the double dorsal tubercle on the 8th abdominal segment is shown at Figure 10, *d'*; *sd*, the subdorsal ones; *a*, a seta much enlarged, which, unlike *T. polyphemus*, is finely and minutely barbed; *a'*, *a''*, ends of other setæ.

Stage II.—Moulted May 26, in the daytime. Length at first 9 mm., afterwards 10 mm. In one larva all the tubercles are of the same yellowish hue; in the other, those of the 2d and 3d thoracic segments are brownish at the tip, thus greatly contrasting with the others. In another larva the median dorsal tubercle on the eighth uromere is also colored in the same way. The head in one is all green, not yet banded with brown; but in another the head is partly banded, i. e. in place of the two-scalloped band are two separate short scallops.

The tubercles are now *higher than before*, and rough with slender conical warts which give origin to the setæ. The prothoracic tubercles

are now *longer than before*, and all four are deep amber-yellow at the end, the setæ being black; two out of the five spines of the 2d and 3d thoracic segments are dark brown at and near the ends, and give rise to black bristles, rendering them very conspicuous; they are a little larger and higher than those on the abdomen, and bear about twice as many bristles; eight in all, all of which are black, while on the yellow tipped tubercles of the abdominal segments there are about five bristles, one of them minute; two of the five are black, the others pale. The two lateral rows of tubercles are, as before, with pale bristles.

The median dorsal tubercle on the 8th uromere is not quite so dark as those on the 2d and 3d thoracic segments, and some of the latter are scarcely darker than the other abdominal ones. The spiracles are of the same pale color as before. The suranal plate still bears the two terminal tubercles, as before. The thoracic legs are now darker than before.

In this stage the larvæ sometimes assume a sphinx-like attitude.

Stage III. — Moulded June 1. (I am not sure that it was the same larva; one moulted May 31. Described three days after moulting.) Length 13 and finally 15 mm. The head is either banded as before, or all green, only the ocelli being black. The body is now thick, though differing very slightly from the preceding stage. The four prothoracic, the two dorsal 2d and 3d thoracic tubercles, and the single median dorsal tubercle on the 8th uromere are either deep crimson red at the end, or much paler, and in the largest one yellowish, the tips of these tubercles varying a good deal in color; *these tubercles are now nearly twice as long and thick as those on abdominal segments 1 to 7 and 9.* The tubercles of the two lateral rows are of the same size as before; those of the upper (supraspiracular) row are still green and small; those below, situated on the lateral ridge, are salmon-colored, and provided with black setæ, like those arising from the dorsal tubercles; near, and on the base of and between the tubercles are *white, delicate clavate hairs* (glandular?) which are not observable in the preceding stage; they are mostly confined to the abdominal, few, only one or two, on the thoracic region.

The thoracic legs are dark brown, pale at the tip; the abdominal legs except the anal pair, are green, with a transverse lilac line near the ends; beyond yellowish, while the plantæ are tinged with lilac. There is as yet no lilac tinge on the edge of the suranal plate.

Stage IV. — (Belonging to a later different brood; described July 24.) Length 23 mm. The head now pea-green, *not banded in front*, nearly as wide as the body; well rounded, and of the same shape as

in *T. polyphemus*; it is of a deeper pea-green than the body, which is in general, especially on the dorsal side, paler than in *T. polyphemus*. The labrum and jaws are pale. There is a chestnut-colored ocellar patch.

The segments are now *quite convex*, swollen under the base of the tubercles, the 2d and 3d thoracic segments being fuller and more angular than the uromeres; they are a little more so than in *T. polyphemus*.

The four dorsal tubercles of the 2d and 3d thoracic segments (two each) are larger than the abdominal ones, and *are tipped with dark carmine* at the end, and each, besides one or two short setæ, bears a long black slender hair, about as long as the body is thick; the corresponding hairs on the abdominal tubercles being about one third as long. There are four well developed prothoracic tubercles, the dorsal ones larger, more rounded and prominent than in *T. polyphemus*, and also bearing besides three or four small, short pale hairs, and a black very long one. The prothoracic tubercles are *deep rosy pink*, not coral-red. The lateral ones on the same segment are nearly twice as large as those behind in the same series, and all on the body are rosy pink or "crushed strawberry" color. The lateral infraspicular ridge along the abdominal segments is distinctly lemon-yellow. The spiracles are faint reddish green, quite inconspicuous. The thoracic legs are reddish. The middle abdominal legs are green above, below is a narrow distinct black stripe, the end yellow, while the planta is livid flesh-color; the anal legs with an anterior oblique yellow band, and a black spot corresponding to the black stripe, with black hairs above, as on the middle legs. The suranal plate is faintly edged with yellow.

The larva in this stage differs from *T. polyphemus* of the same age in the *green* head, the distinct lateral yellow stripe below the spiracles, which are *green*, and not readily seen. The six dorsal thoracic tubercles are distinctly *larger and more prominent* than the abdominal ones, and they each bear a single very long slender black hair, besides one or two short ones; this is a good generic character, separating it at once from *T. polyphemus*, and the suranal plate is not edged with purple, but with faint yellow.

When fully fed,* its length is 65 mm. Maine, August 20. The head is green, of a different hue from the body, more like Paris-green. The body is large, heavy, plump, and thick, much as in *T. polyphemus*, and the tubercles are pinkish red, or crushed strawberry. The suranal

* Dyar states that there are but four stages.

plate is edged with yellow in front, but the surface is coarsely granulated, and in color dull amber; there is a similar long narrow patch on the side of the anal legs, bordered above with black and straw-yellow. The spiracles are green with the edge of the linear opening ochreous. The yellow lateral line is obscure. The body is still provided with white hairs, not arising from tubercles. The body is pea-green, dorsally slightly tinged with ruddy.

Recapitulation of the more Salient Ontogenetic Features.

A. Congenital Features.

1. Setæ tapering to a point, not bulbous, and finely barbed. Stage I. Most of them are three or four times as long as the tubercles.
2. Some larvæ in Stage I. with a very broad lateral dark band along the side of the body, some without it; no transverse stripes present, but the head in front is twice banded with dark brown.
3. The 2d and 3d dorsal thoracic tubercles differentiated in Stage I., being slightly larger than the abdominal ones.
4. On the suranal plate are two rudimentary tubercles, each bearing a tuft of bristles.
5. The dorsal median tubercle on uromere 8 does not show such marked traces of its double origin as Stage I. of *C. promethea*, or *T. polyphemus*, but it is more duplex than in *P. cecropia*.

B. Evolution of later Adaptational Characters.

1. Dorsal tubercles in Stage II. higher than before.
2. The lateral dark band disappears in Stage II.
3. In Stage III. the dorsal thoracic tubercles become nearly twice as long and thick as the abdominal ones.
4. The head is not banded in Stage IV.
5. The tubercles brightest (pink or dark carmine) and most conspicuous in the last stage.
6. A distinct infraspicular yellow line in Stage IV., and the suranal plate and anal legs lined with yellow, and the surface of the suranal plate and sides of the anal legs amber.